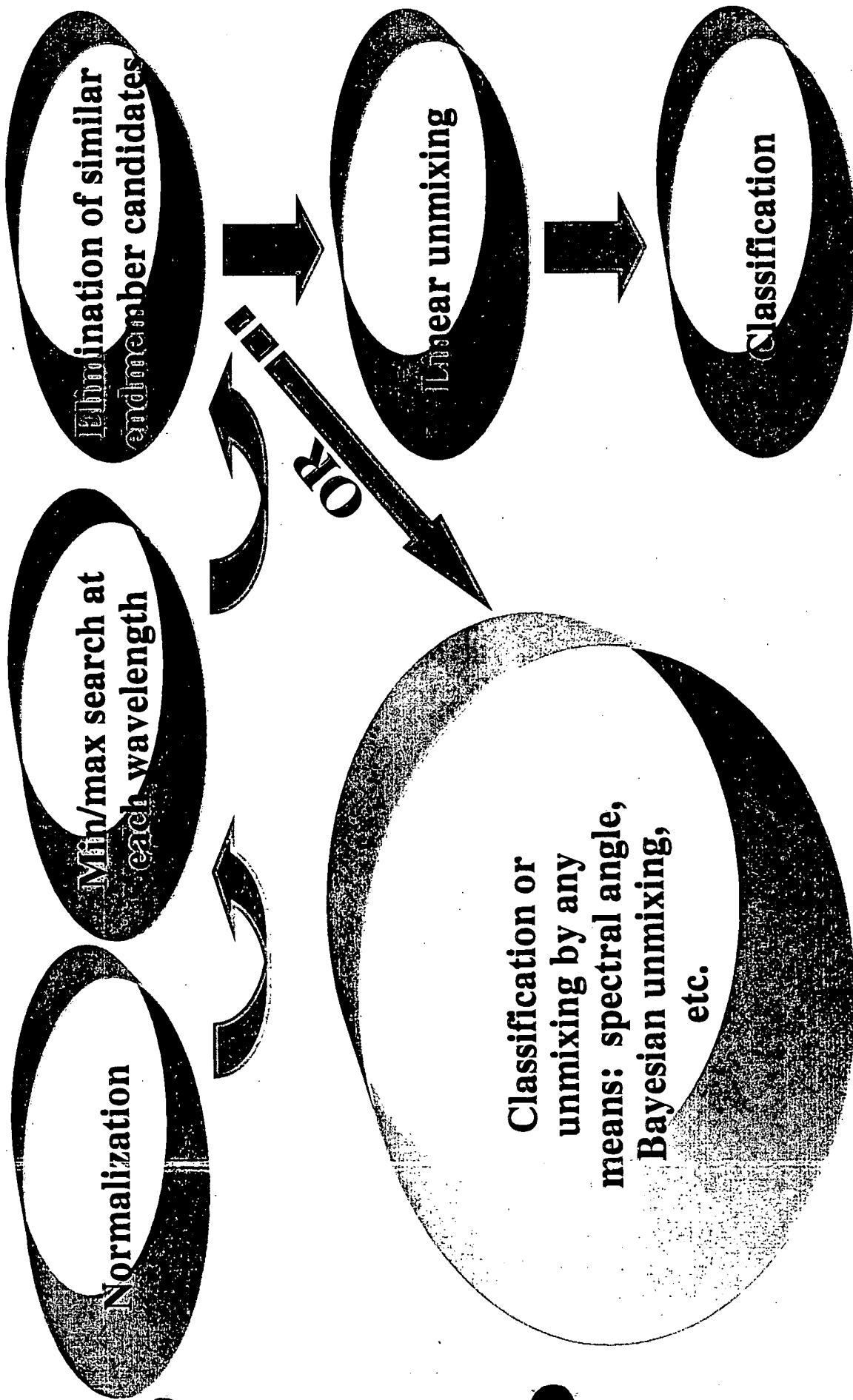


ALRED

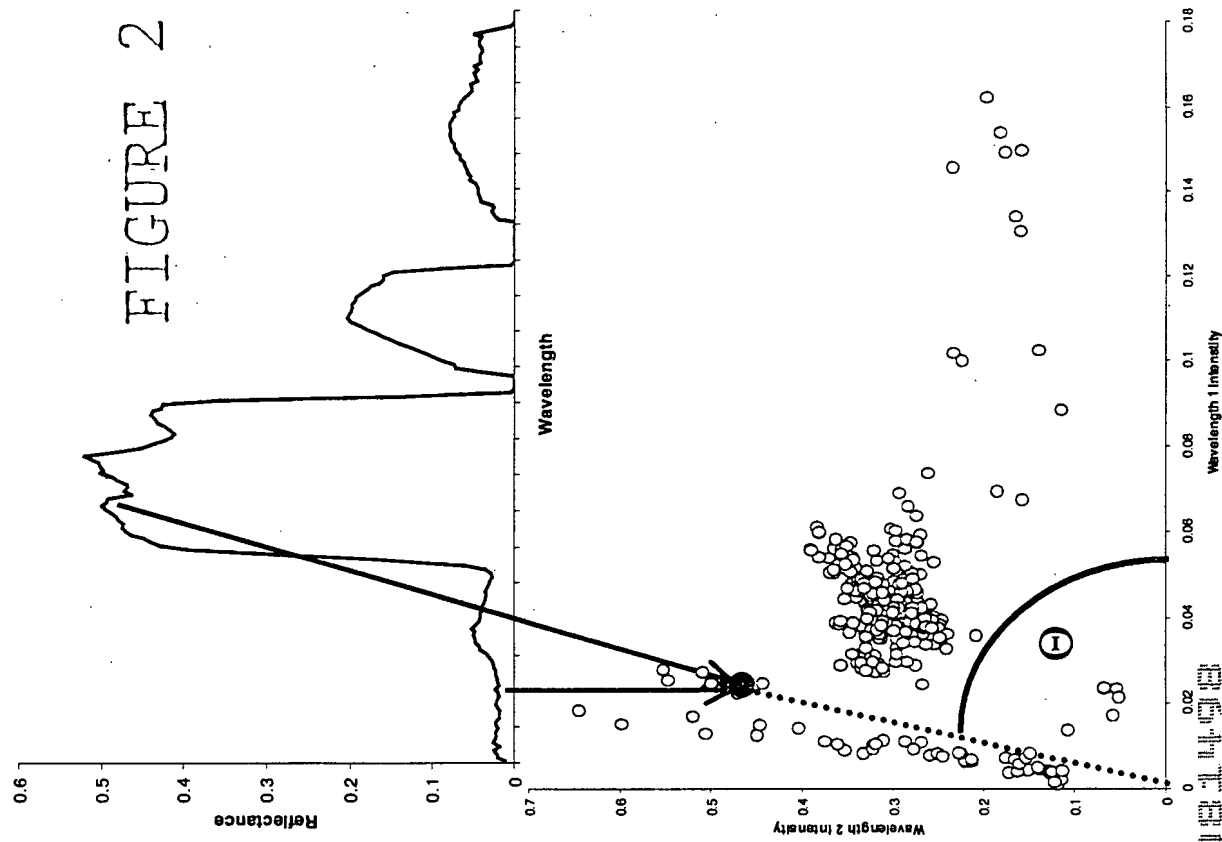


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SPECTRAL ANGLE

- Treats spectra as vectors in a multi-dimensional space
- Coordinate axes of this space are the individual wavelengths for the spectra

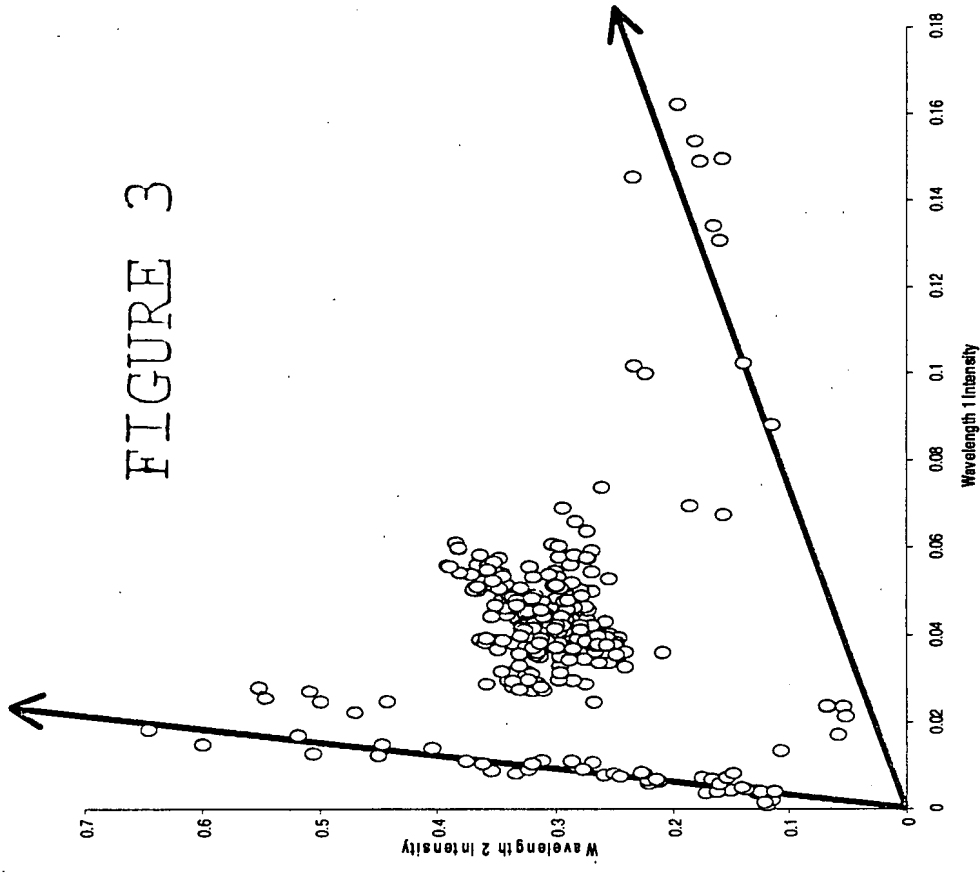




Spectral Angle Clustering

- The shape of a spectrum is represented by its spectral angle
- Supposition: items with the same reflectance spectrum with different illuminations should have the same spectral angle, but different apparent reflectance magnitudes
- Objects of similar spectral shape should cluster along *directions* even when illumination varies

FIGURE 3





Principal Components Analysis

- PCA is used to reduce the dimensionality of the data set
- PCA also further separates classes of pixels along spectral angle
- Time consuming, but vital to reducing the search time for clusters along spectral angle directions

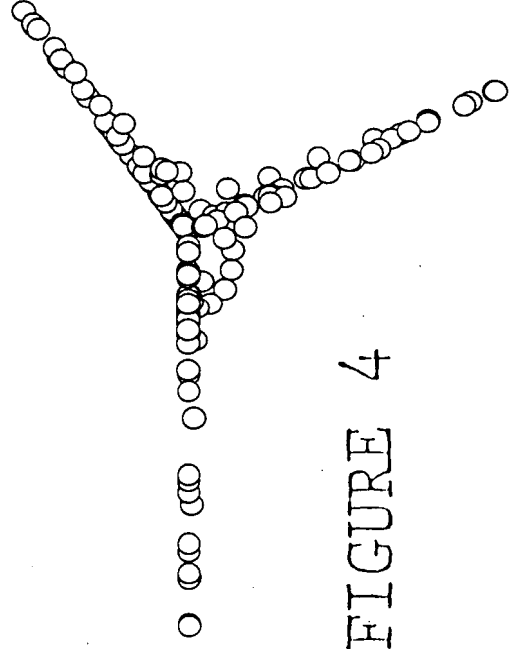
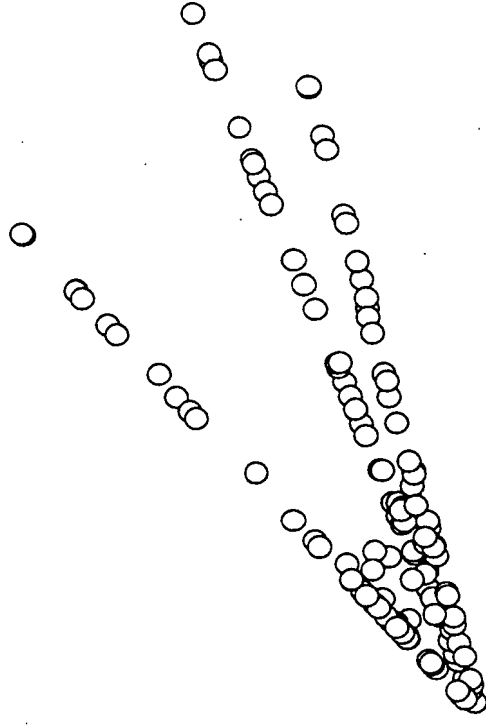
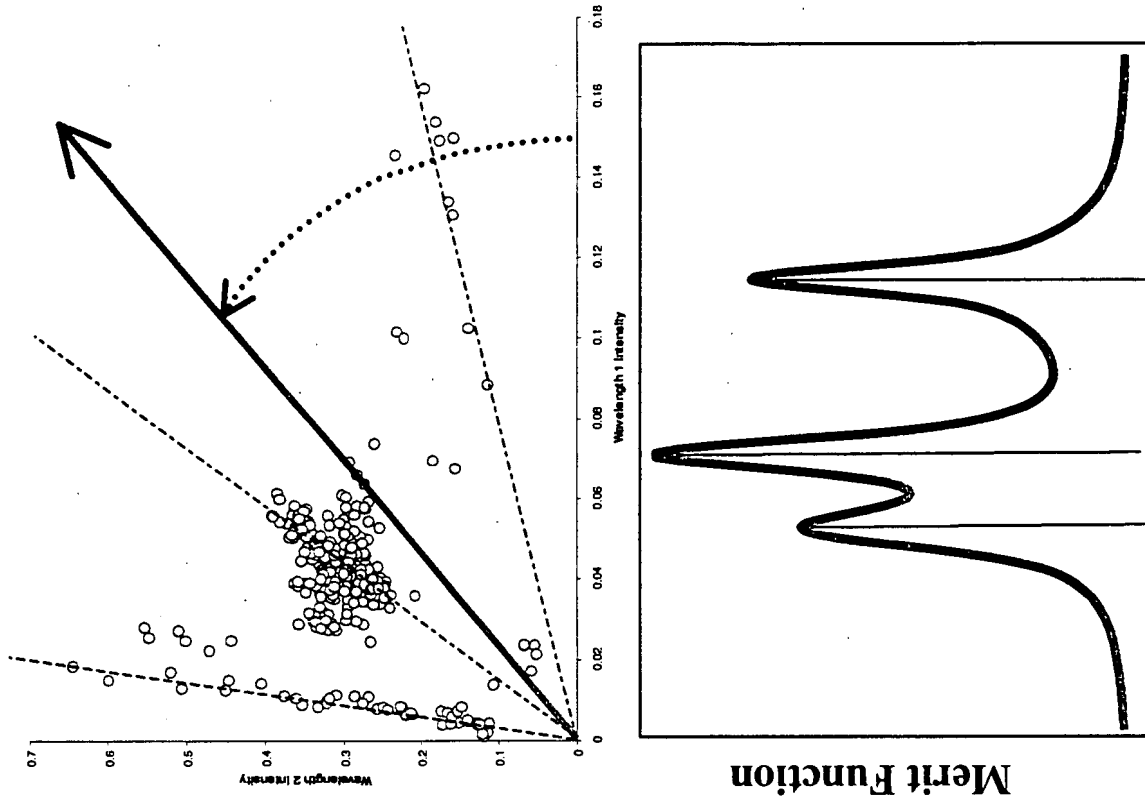


FIGURE 4



PATTERN RECOGNITION

- A line from the origin is incrementally swept through the data
- At each angle, a merit function is calculated for the data with respect to that angle
- The merit function preferentially weights points along the chosen angle and far from the origin (to be resistant to noise)
- Peaks in the resulting merit function map represent a distinct class of objects

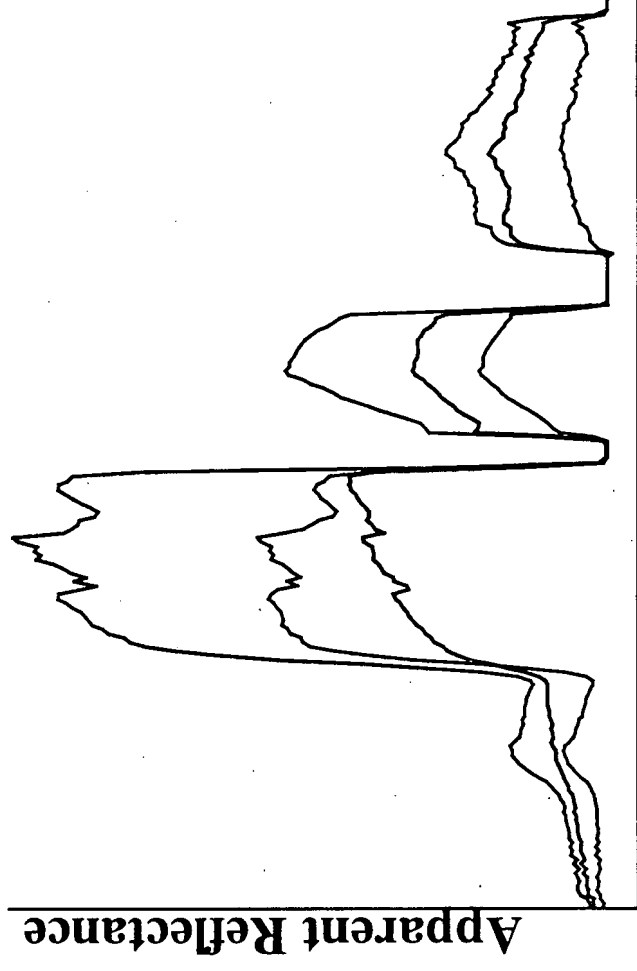
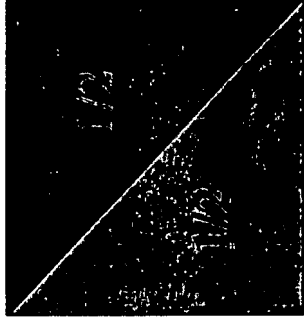


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Angle
FIGURE 5



BAYESIAN UNMIXING

- Converts spectra into probability distributions
- Uses Bayes' Theorem to 'unmix' the fractional contribution of each endmember
- Constrains the unmixing result to have coefficients for each endmember $0 \leq C_i \leq 1, \sum C_i = 1$



Wavelength

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FIGURE 6



CONVEX HULL MODEL

- Endmembers are corners of simplexes fit around the data set
- Points inside of simplex are linear combinations of the vertices with coefficients summing to one.
- Different view of things than Spectral Angle

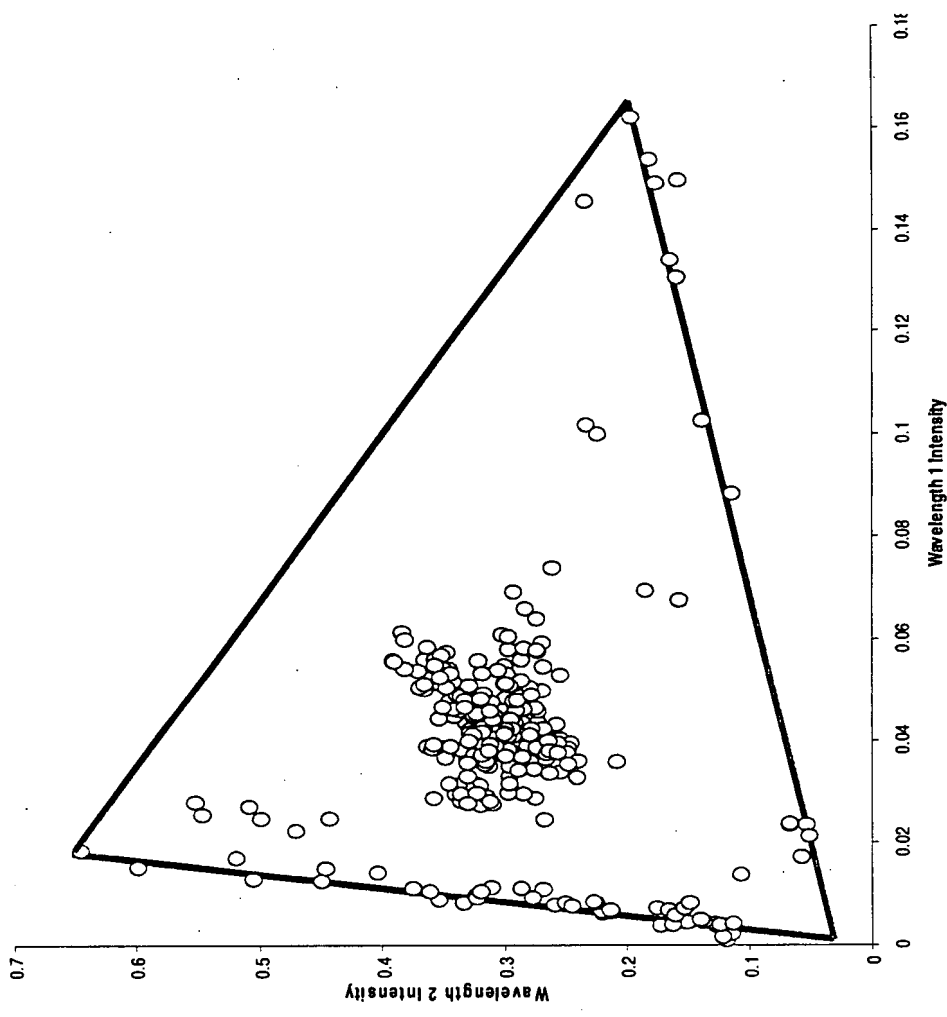


FIGURE 7

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FAST ENDMEMBER RETRIEVAL

- Outliers in magnitude at individual wavelengths are good endmember candidates -- and are EASY to find

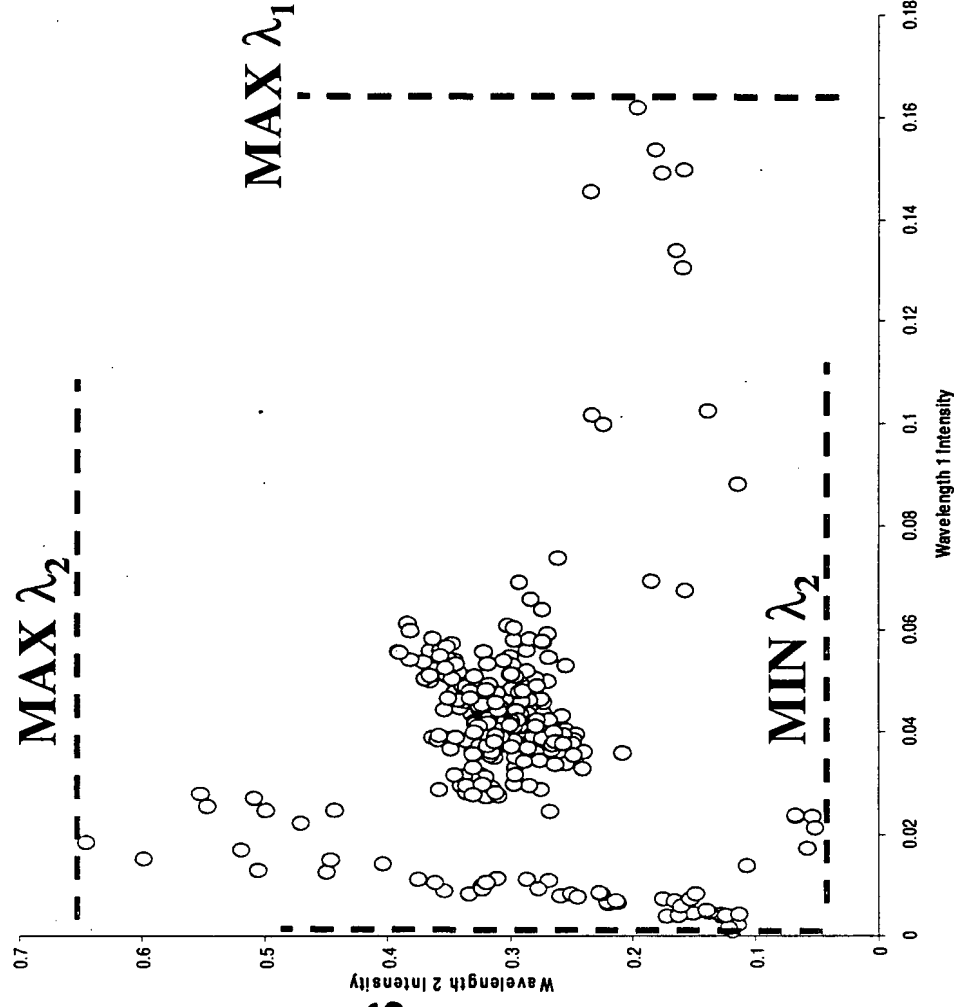
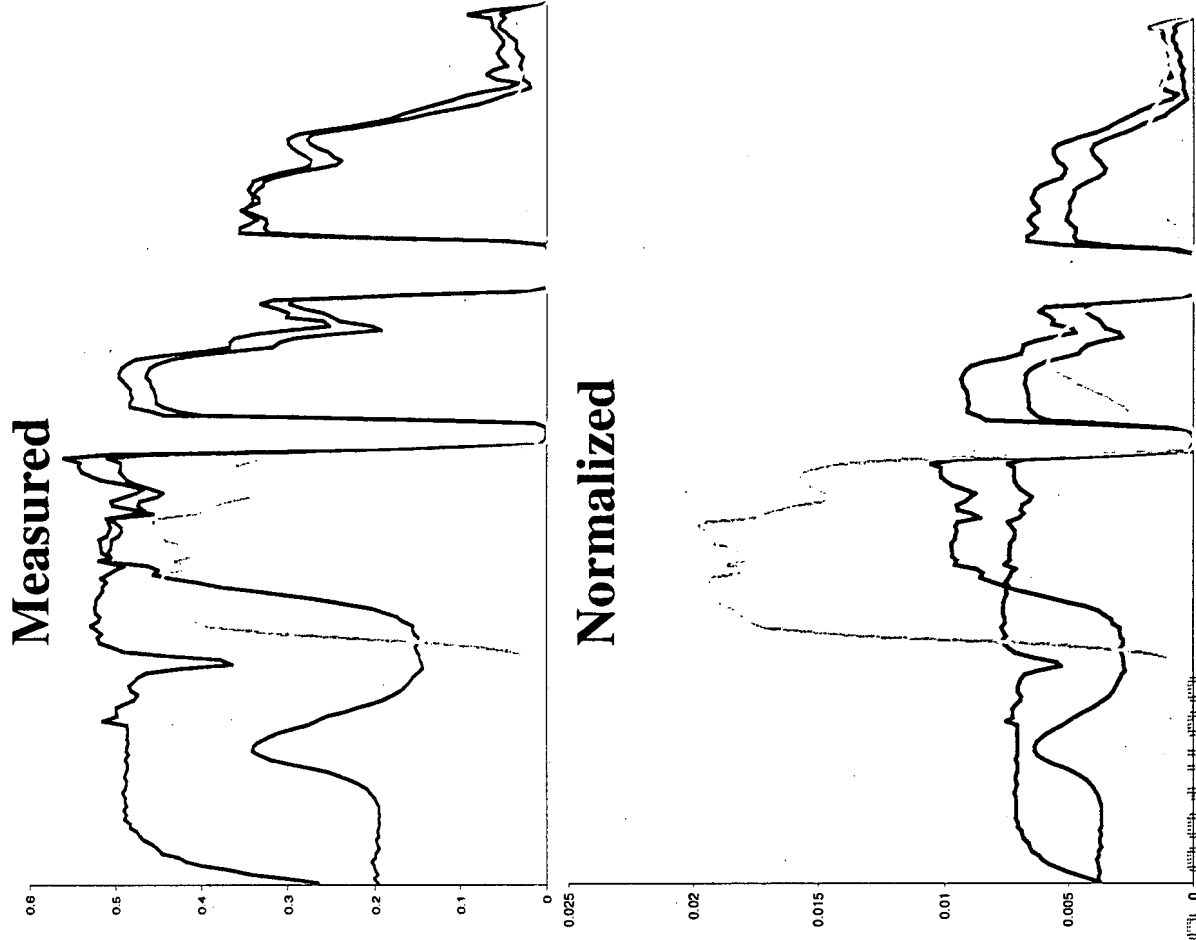


FIGURE 8



NORMALIZATION

- The min/max approach will not always find the simplex vertices
- Simplex vertices don't tell the whole story -- we really want unique spectral shapes
- Pixels with unique spectral shapes may be missed due to pixels with overall higher reflectance or greater illumination
- Normalization solves this -- note that we are no longer really trying to grab simplex vertices



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FIGURE 9